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WORK CHAMBER WITH AN AUTOMATICALLY SEALABLE PASSAGE FOR A MANIPULATOR ARM REACHING INTO THE WORK CHAMBER

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WORK CHAMBER WITH AN AUTOMATICALLY SEALABLE PASSAGE FOR A MANIPULATOR ARM REACHING INTO THE WORK CHAMBER

[Arbeitskammer mit einer automatisch abdichtbaren Durchführung für einen in die Arbeitskammer eingreifenden Manipulatorarm]

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The invention pertains to a work chamber with an automatically sealable passage for a manipulator arm reaching into the work chamber.

In many branches of industrial production, automatically controllable handling devices (manipulators) are used to automatically load and unload workpieces for machine tools and processing stations. Gantry robots, which can move linearly in a Cartesian coordinate system, have proven to be effective for placing equipment on machines, so that positioning tasks can be calculated easily and executed at a quick rate. However, the use of such gantry robots is difficult for processing stations, e.g., painting cabinets or abrasive blasting chambers, which are partitioned

from the surroundings by a work chamber. To protect the manipulator from contaminants and/or damage, it is necessary to arrange these manipulators outside the work chamber and to allow only individual elements, e.g., the gripper for the workpiece, to project into the chamber. At the same time, however, contaminants must be prevented from getting out of the chamber through seals at the point of passage.

From US 4,882,881, a positioning device is known, which moves on the top side of a closed chamber and which reaches into this chamber from the outside, so that workpieces can be positioned within the chamber. To stop particles from getting out of the work chamber into the surroundings when the positioning device moves during the continuous workpiece processing, very expensive sealing arrangements are provided. However, the positioning device and the associated sealing arrangements can move in only two directions, so that positioning processes cannot be performed for arbitrary orientation of the workpiece in space.

In industrial production, manipulators are also used to hold and/or guide individual workpieces during processing in shielded work chambers when the presence in these work chambers is dangerous to human health or not advisable for other reasons. With multi-axis manipulators, it is possible to guide the workpiece along a three-dimensional track and in this way to change the orientation of the workpiece, e.g., relative to an abrasive blasting nozzle or painting nozzle, during the movement. For the guidance of workpieces in the effective area of painting nozzles, abrasive blasting devices for abrasive surface treatment or the like, industrial robots with a 6-axis bending arm kinematic system, which include three bending axes and three rotating axes, have proven to be effective. With such a kinematic system, any point in the working space of the industrial robot can be reached with arbitrary spatial orientation of the final axis.

From DD 234 823 A1, an abrasive blasting chamber arrangement is known, in which an abrasive blasting nozzle is guided by means of a six-axis industrial robot and acts on a stationary workpiece, which is held on a moveable cart. The nozzle can be positioned arbitrarily in the work chamber due to the six degrees of freedom of the industrial robot, so that the workpieces can be treated from all sides. Automation enables high throughput. However, here it is disadvantageous that the system is not suitable for large-area blasters with fan blowers, because these can be operated only when stationary and due to their large weight they are not suitable for positioning by means of a manipulator. Because the robot is shielded from the work chamber by a rigidly mounted, slatted seal, it is not possible in this system, due to the undetachable seal, to insert the workpiece into the chamber with the industrial robot, to guide the workpiece in this chamber, and then to take it out again.

Another system of this type is disclosed in US 6,004,190 A. Here, the industrial robot, which reaches from the outside into the partitioned work chamber and which guides an abrasive blasting nozzle, is also connected by a flexible but rigidly mounted seal to the wall of the work

chamber. Thus, no workpieces can be inserted into the work chamber and retrieved with the industrial robot.

Therefore, the problem has been presented of providing a work chamber with a passage, through which a manipulator arm can reach into the chamber, with the passage being sealable automatically in the chamber before the beginning of the work, so that particles can be prevented from getting out of the work chamber during the processing.

This problem is solved by a work chamber with an automatically sealable passage for a manipulator arm reaching into the work chamber, with

at least one work-chamber wall provided with a recess;

a passage pipe, which is inserted into the recess in the work-chamber wall and which is connected to this wall;

a hollow, flexible sealing element, which can be pressurized with compressed gas via a valve, which can be pulled onto a manipulator arm in a sealed connection by means of its one or more inner recesses, and which has a wall completely enclosing the manipulator arm, wherein this wall can contact the inner wall of the passage pipe element when the sealing element is pressurized with compressed gas.

In the following, the term "torus" is understood to be a body, which is defined by rotating a circular cross section along a circular path.

The term "semi-torus" should be understood to be a body, which produces an annular body with semicircular cross section for a torus cut in the plane of the circular path.

An elongated body with a circular, ellipsoidal, or polygonal cross section is specified as the passage pipe.

Advantageously, in the work chamber according to the invention, a secure sealing of the manipulator arm in the passage can be established and detached again automatically, thus without assembly steps or other manual interventions. In this way, the manipulator arm can be moved during processing while maintaining the seal within the passage.

With the configuration of the work chamber according to the invention, individual workpieces can be inserted into the work chamber. The seal can be created automatically immediately before the processing in the chamber, e.g., by means of a program sequence controller, which opens a pneumatic valve and thus lets compressed gas into the sealing element, whereby the flexible sealing element is inflated and contacts the passage pipe from the inside. Action by operating personnel is unnecessary.

After completion of the processing in the chamber, the seal on the passage pipe can be automatically removed again, so that the manipulator arm can move freely and can be moved with the workpiece out of the chamber.

It is also advantageous if the manipulator arm does not absolutely have to be arranged coaxial with respect to the passage pipe and also if it can be shifted within this pipe, so that the position of the manipulator arm in the passage pipe does not have to be defined or adjusted exactly. The work chamber of the invention still enables movement of the manipulator arm, which is sealed in the passage pipe, in up to five degrees of freedom during the processing in the chamber, namely:

a translating movement parallel to the axis of the passage pipe,

a rotation about the longitudinal axis of the manipulator arm,

a two-dimensional shifting of the longitudinal axis of the manipulator arm relative to the axis of the passage pipe, in the cross-sectional plane of the passage pipe, as well as

an inclination of the manipulator arm relative to the center axis of the passage pipe.

Because only the end element of the manipulator needs to reach into the chamber, important components of the manipulator, which also contain the electric drives, can be arranged outside the chamber and thus outside the area with particles.

A first essential feature of the invention is that the sealing element have at least one inner recess, so that the sealing element can be pulled onto the manipulator arm and the manipulator arm and sealing element can be connected in this way in a particle-tight connection. Another essential features is that the sealing element be hollow and inflatable via a valve with compressed gas, e.g., compressed air. As long as the gas has been bled out of the hollow body formed by the sealing element, the manipulator arm with the slack sealing element can be guided easily through the passage tube. Then the sealing element is expanded in volume through pressurization until it is pressed against the passage pipe.

In one especially simple and economical embodiment, the sealing element has a torus shape like an inner tube.

In another embodiment, the sealing element is tubular and comprises an outer hose, a front-end semi-torus, a rear-end semi-torus, and an inner hose that can be pulled onto the manipulator arm in a sealed connection, wherein the outer periphery of the semi-torus is connected to one end of the outer hose and the inner periphery is likewise connected to the inner hose accordingly. The flexible sealing element has the shape of a double-walled pipe when it is inflated and lies between the manipulator arm and passage pipe. Here it is advantageous that an elongated shape be produced, wherein the contact area between passage pipe and sealing element expands and the sealing effect, especially for movements of the manipulator arm in the passage pipe, is improved.

In one preferred embodiment, the sealing element is formed with a tubular shape from an outer hose, a front-end semi-torus, a rear-end semi-torus, and two annular flanges that can be pulled onto the manipulator arm in a sealed way, wherein the outer hose is connected on the ends to the outer periphery of the semi-torus and the inner periphery of the semi-torus is attached to an

annular flange. Here, an increased sealing effect is also achieved. The rigid connection of the sealing element to the manipulator arm via the annular flange also prevents stripping of the sealing element by the movements of the manipulator arm in the continuing operation.

An embodiment is also advantageous, for which the passage pipe has at least one flushing nozzle and/or gas nozzle pointing in the direction of the interior of the work chamber. The flushing nozzle can be operated with fluids and the gas nozzle can be operated with compressed air. After bleeding the gas from the sealing element, an open annular gap is produced between the outer periphery of the sealing element and the inner periphery of the passage pipe. Contaminants, which have penetrated into this annular gap during processing, can be blown or flushed back into the chamber with the one or more nozzles.

Additional advantageous configurations follow from the additional subordinate claims, as well as from the examples described below.

The invention will be described in more detail below with reference to the drawing. Shown in detail are:

Figure 1, a cut-out of an abrasive blasting chamber with an industrial robot reaching from the outside in a lateral sectional view;

Figure 2a, an automatically sealable passage in the work chamber with a manipulator arm inserted into this passage in a schematic sectional view;

Figures 2b-2d, the passage from Figure 2 with various positions of the manipulator arm, each in a schematic sectional view;

Figures 3a, 3b, [sic; 3a-3c] a work-chamber wall that can be divided with sliding-door elements in various positions in a view from the front; and

Figure 4, another configuration of an automatically sealable passage and manipulator arm inserted into this passage in a schematic sectional view.

In Figure 1, a cut-out of an abrasive blasting chamber 10 is shown. A fan blower 110 shown as a cut-out and for abrasive surface treatment is arranged in the abrasive blasting chamber. A rotating feed screw 120 is provided on the bottom of abrasive blasting chamber 10 in order to feed abrasive blasting material falling onto the bottom for the purpose of preparation and reuse out of the abrasive blasting chamber 10. An industrial robot 30 is arranged outside abrasive blasting chamber 10. The industrial robot 30 has six axes 31.1, 32.1, 33.1, 34.1, 35.1, 36.1 and thus six degrees of freedom. The height axis 31.1 is a rotating axis, about which the entire industrial robot 30 can rotate relative to the foundation 130. In succession are two bending axes 32.1, 33.1, with which the so-called upper arm 32.2 and the lower arm 33.2 can be inclined. In this way, the so-called wrist joint 35.1, which is another bending joint, can be positioned in space. The orientation of the wrist joint 35.1 relative to the lower arm 33.2 can also be changed by a rotating axis 34.1. By means of the rotating hand axis 36.3, the robot hand 36.2 with the gripper 37 attached

to this hand can be rotated. The gripper can have two or, especially for round workpieces, more clamping fingers and can be activated electrically, pneumatically, or hydraulically, as is known.

The curve 39 specifies the working space that can be reached by the industrial robot 30 with the wrist joint 35.1.

A workpiece 200 is held in the gripper 37 of the industrial robot 30 and in this way is guided through the effective area of the fan blower 110. The wrist joint 35.1 and the robot hand 36.2 with the gripper 37 are located inside a passage pipe 12 guided through the work chamber wall 11 for the processing situation shown in Figure 1. A hollow, flexible sealing element 20 is pulled onto the robot hand 36.2. This sealing element is inflated with compressed air and pressed against the inner wall of the passage pipe 12, so that particles are prevented from getting out of the interior of the work chamber 10.

The sealing of the robot hand 36.2 at the passage through the work-chamber wall 11 and the movements possible with this seal within the passage pipe 12 are shown in Figures 2a-2d.

In the starting position shown in Figure 2a, the robot hand 36.2 is located within the passage pipe 12 inserted into the work-chamber wall 11. The center axes of the robot hand 36.2 and the passage pipe 12 coincide. A sealing element 20 is pulled onto the robot hand 36.2. This sealing element has been inflated with compressed air, so that said compressed air contacts the inner wall of the sealing element 20 and fills the annular gap between the robot hand 36.2 and the sealing element 20 over the entire periphery.

The robot hand 36.2 can be moved according to the invention within the sealing element 20 and while maintaining the seal created by the sealing element 20 as follows:

shifting parallel to the center axis of the sealing element 20 along a robot hand shifting direction designated with 41;

two-dimensional shifting of the robot hand 36.2 in the cross-sectional plane of the passage pipe 12, either in a vertical wrist joint shifting direction designated with 42 or in a horizontal wrist joint shifting direction designed with 45 (cf. Figure 3c);

rotation of the robot hand 36.2 about the robot hand axis 36.3 (cf. Figure 2c) in the robot hand axis rotating direction designated with 43; and

inclination of the robot hand 36.2 relative to the pipe center axis of the passage pipe 12 by pivoting the wrist joint 35.1 in the wrist joint pivoting direction designated with 44.

As Figure 2b shows, the robot hand 36.2 has been shifted by a translating movement in the direction of arrow 41 into the work chamber 10. Here, the sealing element 20 has partially emerged from the passage pipe 12. However, it still lies with a sufficient portion of its volume within the passage pipe 12, so that the seal can be maintained.

The sealing element 20 comprises a front semi-torus 21 and a rear semi-torus 22, whose outer peripheries are connected by an outer hose 23, as well as two annular flanges 26, 27, by

means of which a fixed coupling of the corresponding inner periphery of each semi-torus 21, 22 to the robot hand 36.2 is created.

In Figure 2c, a position is shown, in which the robot hand 36.2 has been raised by a shifting of the wrist joint 35.1 in the wrist joint shifting direction 42. The robot hand axis 36.3 lies above the not-shown center axis of the passage pipe 12. In the illustrated position, the sealing element 20 has a small volume above the robot hand 36.2. Due to the pressurized expansion on all sides in the hollow sealing element 20, with the upwards motion of the robot hand 36.2, a greater amount of compressed air has been forced into the lower region, so that the seal is maintained there.

In the passage sealed according to the invention, the seal is even preserved for a manipulator arm reaching into the work chamber when the robot hand 36.2 is pivoted about the wrist joint axis 35.1 also designated with 44 after the shifting 42 shown in Figure 2c, so that the robot hand axis 36.3 is inclined relative to the center axis of the passage pipe 12, as shown in Figure 2d.

Preferably, as Figure 3b shows, the work-chamber wall is formed in two parts, in the form of two sliding-door elements 11.1, 11.2 that can shift relative to each other. The passage pipe 12 is also formed in two parts from two shells 12.1, 12.2, which are each inserted into the sliding-door elements 11.1, 11.2 in the region of the contact edge 14. If the sliding-door elements 11.1, 11.2 lie against the contact edge 14, then the shells 12.1, 12.2 integrate into the passage pipe 12. Through partition, the work chamber 10 can be opened between the sliding-door elements 11.1, 11.2 pushed away from each other to such an extent that large workpieces, which can no longer be led through a one-piece passage pipe 12, can also be introduced into the chamber with the industrial robot 30. In addition, the cycle time can be shortened, because waiting for the sealing element 20 to become completely slack by bleeding the compressed gas is no longer necessary. By opening the sliding-door elements 11.1, 11.2, the robot hand 36.2, along with the sealing element 20, is exposed all at once. The robot hand 36.2 can be transported immediately with the workpiece 200 held in the gripper 37 from the work chamber 10 to an unloading position. During the transport of the already processed workpiece and the loading of another workpiece, the pressure can be gradually bled from the sealing element 20, so that the sealing element 20 is ready for establishing the seal for the next production cycle.

The interaction of the industrial robot 30 with the sliding-door elements 11.1, 11.2 shall be explained with reference to Figures 3a-3c.

Figure 3a shows the opened position of the sliding-door elements 11.1, 11.2 with the shells 12.1, 12.2, after the robot hand that is not shown here is swiveled approximately in the region of the center line 15 into the work chamber 10.

Each of the sliding-door elements 11.1, 11.2 can be shifted by means of a pneumatic cylinder 50. For this purpose, at each end of a piston rod 51 of the pneumatic cylinder 50, a

coupling pin 52 is formed, which can be activated remotely and which engages in a corresponding coupling receptacle 54 on the upper edge of the sliding-door element 11.1, 11.2 in the extended state. By pressurizing the pneumatic cylinder 50, the sliding-door elements 11.1, 11.2 are pushed towards the center line 15 until they contact each other at a contact edge 14 and form a closed work-chamber wall 11, as Figure 3b shows in particular. The shells 12.1, 12.2 simultaneously integrated into a closed passage pipe 12, which surrounds the robot hand. The two sliding-door elements 11.1, 11.2 are in addition connected to each other by a not-shown, remotely activated coupling device.

The coupling pin 52 is then pulled out of the coupling receptacle 54 by remote activation, so that the sliding-door elements 11.1, 11.2 are decoupled from their drive 50. Thus, the package of the sliding-door elements 11.1, 11.2 connected to each other can be moved just by the movement of the industrial robot 30 in the direction designated with 45 in Figure 3c. The robot hand 37 with the held workpiece 200 can be moved within the work chamber 10 over an even greater distance than by the movement of the robot hand within the passage pipe 12.

To protect the robot hand 36.2 and the flexible sealing bellows of the sealing element 20 from contaminants and/or damage, e.g., by abrasive blasting material, a deflector 60 can be arranged between the robot hand 36.2 and the gripper 37, as Figure 4 shows. Abrasive blasting material, which acts in the direction of the passage pipe 12 with the robot 30 guided in this pipe, is held back by the deflector 60. In processes, for which the workpiece 200 only needs to be rotated about the robot hand axis 36.3, without requiring further movement of the robot hand 36.2 within the passage pipe 12, a sufficient seal can be achieved just by the deflector 60. For this purpose, the deflector 60 has an annular channel 62, which surrounds a corresponding projection 13 on the passage pipe 12. The labyrinth seal formed in this way holds back a large portion of the particles from the work chamber 10. By inflating the sealing element 20, an additional, hermetic seal can be created independent of the labyrinth seal.

A labyrinth seal can also be achieved by a deflector, which has at the edges an annular collar surrounding the end of the passage pipe 12 pointing into the interior in a starting position of the industrial robot. The deflector then protects the entrance of the passage pipe 12 like a cover on a bowl. In this way, a sealing effect sufficient for many applications is realized.

List of reference symbols

10	Work chamber
11	Work-chamber wall
11.1, 11.2	Sliding doors
12	Passage pipe
13	Projection

14	Contact edge
15	Door center axis
20	Sealing element
21	Front-end semi-torus
22	Rear-end semi-torus
23	Outer hose
26, 27	Annular flange
31.1	Height axis
32.1	Bending axis
31.2	Upper arm
33.1	Bending axis
33.2	Lower arm
34.1	Rotating axis
35.1	Wrist joint
36.1	Rotating axis
36.2	Robot hand
36.3	Robot hand axis
37	Gripper
39	Working space
41	Robot hand shifting direction
42	Wrist joint shifting direction
43	Robot hand axis rotating direction
44	Wrist joint pivoting direction
50	Pneumatic cylinder
51	Piston rod
52	Coupling pin
54	Coupling receptacle
60	Deflector
62	Annular channel
110	Fan blower
120	Feed screw
130	Foundation
200	Workpiece

Claims

1. Work chamber (10) with an automatically sealable passage for a manipulator arm reaching into the work chamber, with

at least one work-chamber wall (11) provided with a recess;

a passage pipe (12), which is inserted into the recess in the work-chamber wall (11) and which is connected to this wall;

a hollow, flexible sealing element (20), which can be pressurized with compressed gas, which can be pulled onto a manipulator arm in a sealed connection by means of its one or more inner recesses, and which has a wall, which completely surrounds the manipulator arm and which can contact the inner wall (23) of the passage pipe (12) when the sealing element (20) is pressurized with compressed gas.

2. Work chamber (10) according to Claim 1, characterized in that the sealing element (20) has a torus shape.

3. Work chamber (10) according to Claim 1, characterized in that the sealing element (20) has a tubular shape and is formed from an outer hose (23), a front-end semi-torus (21), a rear-end semi-torus (22), and two annular flanges (26, 27) that can be pulled onto the manipulator arms in a sealed way, wherein the outer hose (23) is connected on each end to the outer periphery of a corresponding semi-torus (21, 22) and the inner periphery of each semi-torus (21, 22) is attached to an annular flange (26, 27).

4. Work chamber (10) according to Claim 1, characterized in that the sealing element (20) has a tubular shape and is formed from an outer hose (23), a front-end semi-torus (21), a rear-end semi-torus (22), and an inner hose that can be pulled onto the manipulator arm in a sealed way, wherein the outer periphery of each semi-torus (21, 22) is connected to a corresponding end of the outer hose and the inner periphery of each semi-torus (21, 22) is connected to a corresponding end of the inner hose.

5. Work chamber (10) according to one of Claims 1-4, characterized in that the passage pipe (12) is formed in two pieces from two shells (12.1, 12.2) and the work-chamber wall (11) can be divided at a contact edge (14) and includes two sliding-door elements (11.1, 11.2), which can move relative to each other, each with a corresponding shell (12.1, 12.2) at the contact edge (14), wherein for the sliding-door elements (11.1, 11.2) contacting each other at the contact edge (14), the shells (12.1, 12.2) integrated into the passage pipe (12).

6. Work chamber (10) according to Claim 5, characterized in that the sliding-door elements (11.1, 11.2) can be coupled by means of a coupling element to a translating drive.

7. Work chamber (10) according to Claim 6, characterized in that the coupling element is a coupling pin (52) and the translating drive is acted upon by means of a pneumatic cylinder (50).

8. Work chamber (10) according to one of Claims 1-7, characterized in that the passage pipe (12) has at least one flushing nozzle pointing in the direction of the interior of the work chamber (10).

9. Work chamber (10) according to one of Claims 1-8, characterized by a deflector (60), which can be fixed between a robot hand (36.2) and a gripper (37) of the manipulator arm reaching into the work chamber (10) and which covers the flexible sealing bellows of the sealing element (20) outwards to the work chamber.

10. Work chamber according to Claim 9, characterized in that the deflector (60) has at the edges an annular collar, which surrounds the end of the passage pipe (12) pointing into the interior.

11. Work chamber according to Claim 9, characterized in that the deflector (60) has an annular channel (62) and the passage pipe (12) has a projection (13) compatible with respect to the annular channel (62), wherein in a starting position of the manipulator arm, the annular channel (62) and the projection (13) engage in each other and form a labyrinth seal.

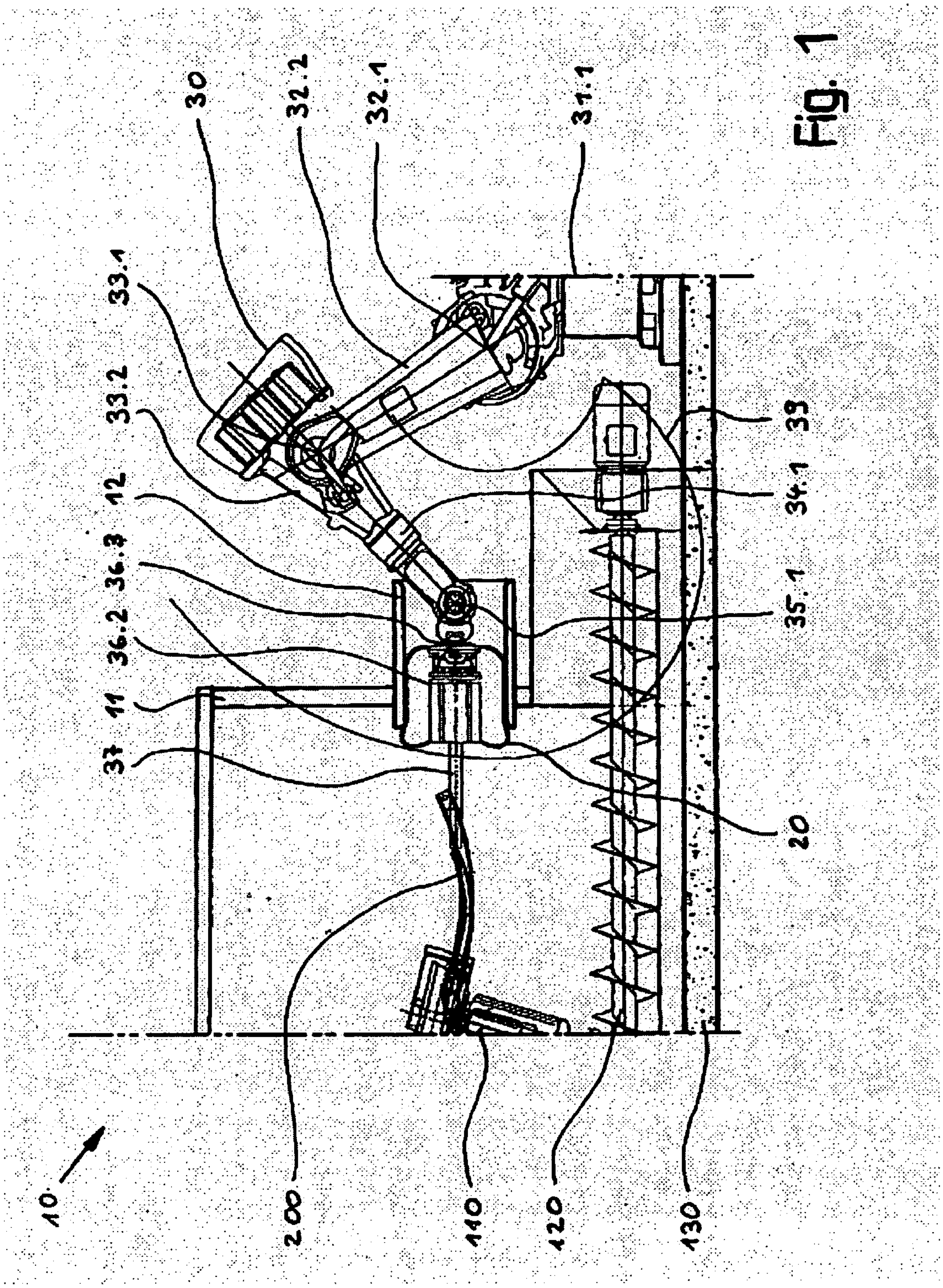
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Fig. 1

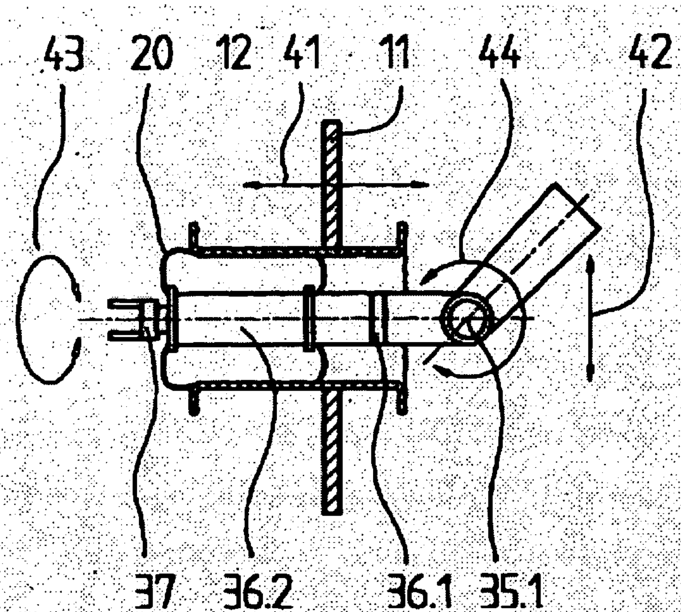

Fig. 2a

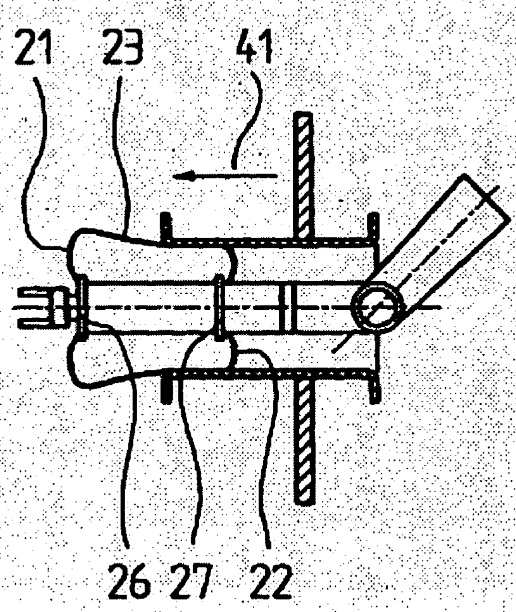

Fig. 2b

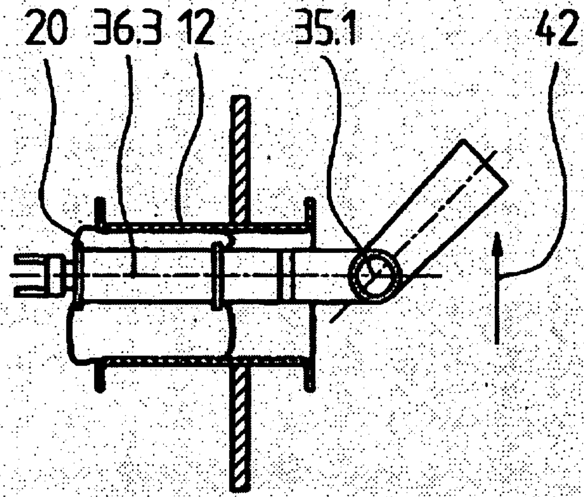

Fig. 2c

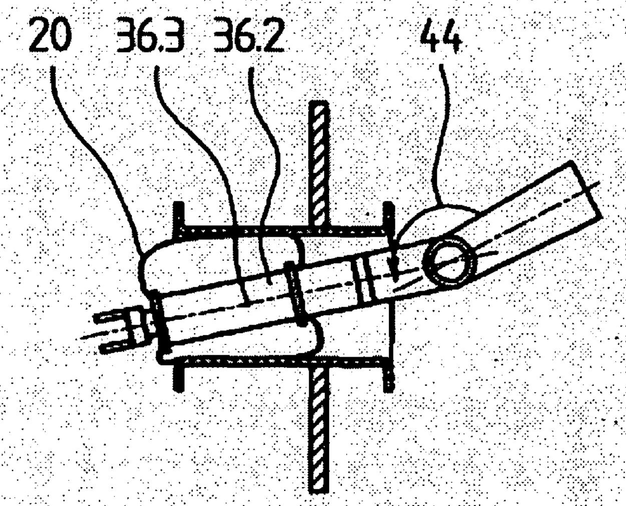

Fig. 2d

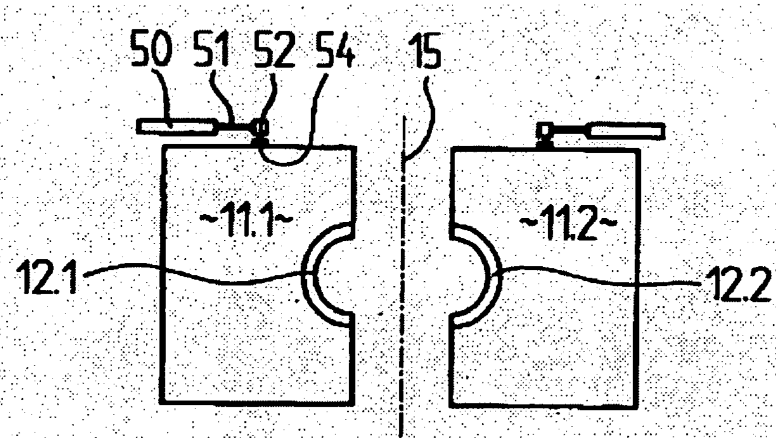

Fig. 3a

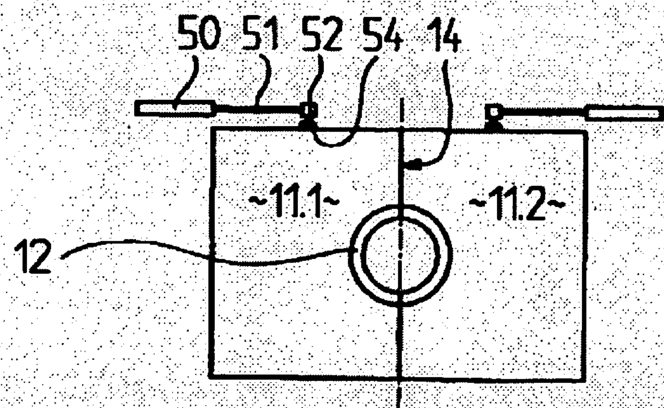

Fig. 3b

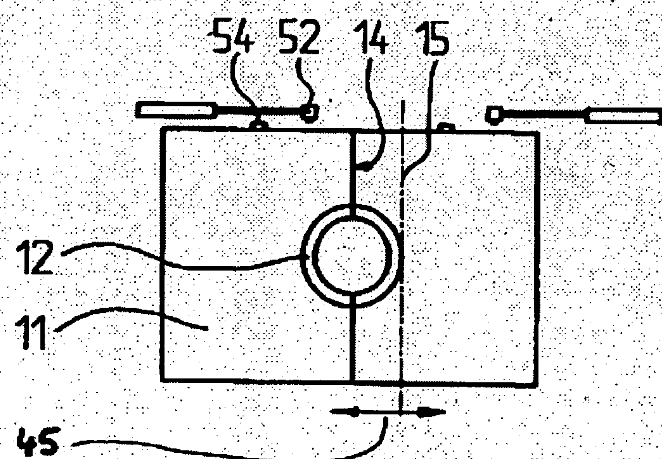

Fig. 3c

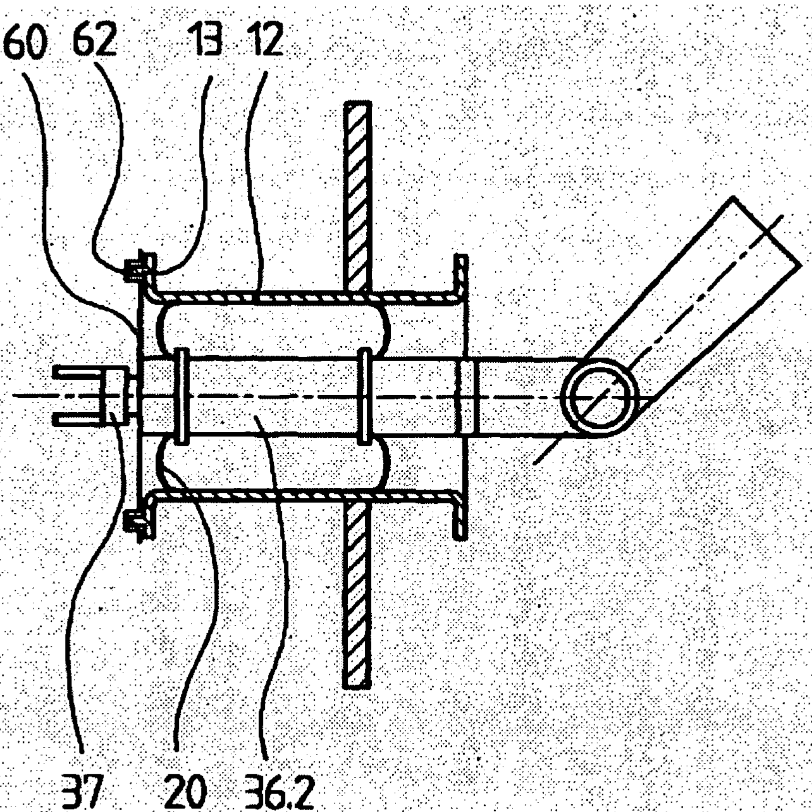

Fig. 4